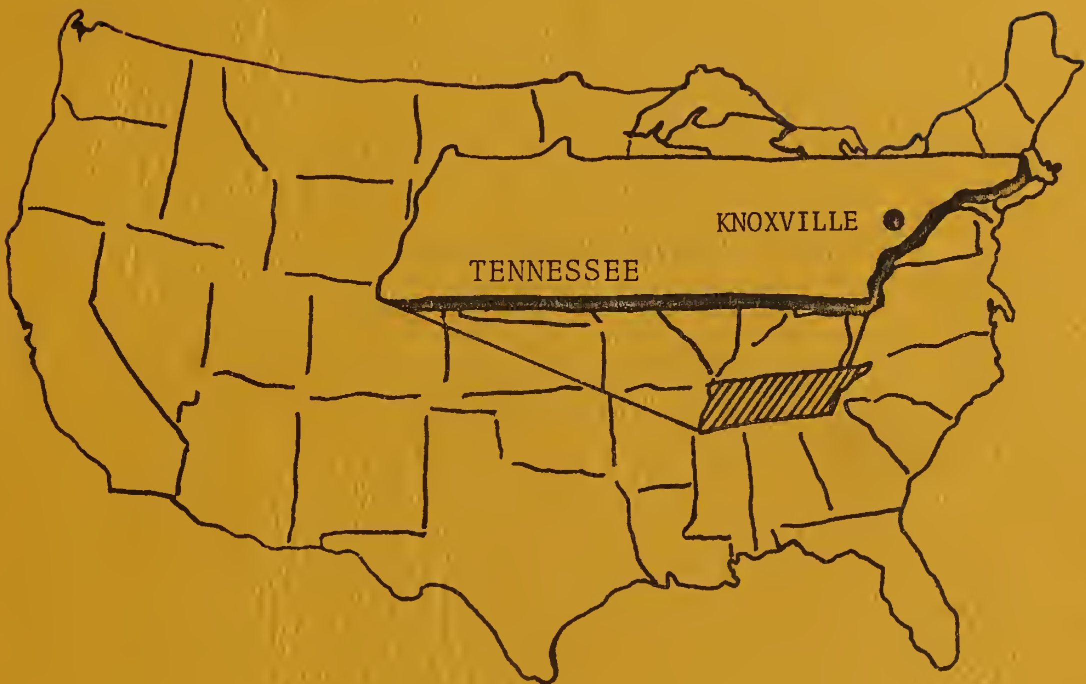
CONSUMER TEXTILES AND CLOTHING RESEARCH



A COOPERATIVE PROGRAM

BETWEEN

USDA TEXTILES AND CLOTHING LABORATORY

AND

COLLEGE OF HOME ECONOMICS

THE UNIVERSITY OF TENNESSEE

CONSUMER
TEXTILES AND CLOTHING
RESEARCH

USDA TEXTILES & CLOTHING LABORATORY

COLLEGE OF HOME ECONOMICS
THE UNIVERSITY OF TENNESSEE
KNOXVILLE

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RESEARCH NEEDS

Since we are all consumers, textile products affect many aspects of our lives. A significant part of our economic resources are used for clothing and other needs that involve textile products. According to the U.S. Department of Commerce, the fiber/textile/apparel industry complex is the nation's largest industrial employer and uses 40% of fibers consumed in the United States. In the mid-1970's, consumer expenditures for apparel alone amounted to $65 billion dollars, and an additional $8 billion dollars were spent for floor coverings and household textiles.

Thus, it is important for consumer satisfaction and cost/benefit that a textiles and clothing research program address itself to developing new knowledge for the most effective selection, care, and use of textile products. More specifically, textile products affect our health and safety, energy consumption, our ability to work and play, and our feelings about ourselves and surroundings. It is timely and relevant to conduct research that will furnish alternatives for the use of textiles in conserving energy and clothing for the handicapped and other groups with special needs, as well as to provide consumers with better information to judge the quality and serviceability of textiles products they purchase. To emphasize the importance of such research is the primary purpose of this brochure.

COOPERATIVE INTERACTION

The joint endeavors of the USDA Textiles and Clothing Laboratory and the Textiles and Clothing Department, College of Home Economics, are based on the philosophy of cooperative interaction. The Laboratory, located on The University of Tennessee, Knoxville campus, is the only Federal research laboratory which has a mission directly concerned with consumer problems in textiles and clothing. Research priorities of the Textiles and Clothing Department also are consumer oriented. Consequently, these two units are mutually complementary and supportive not only in role and scope, but also in terms of benefits generated for consumers of textile products.

Two mechanisms, the Broad Form and Specific Cooperative Agreements, are available for the administration of cooperative efforts. Collaboration under Broad Form Agreements provides for coordination of research projects of mutual interest and sharing of facilities, equipment, and personnel. Specific Cooperative Agreements are considered on a competitive basis by the USDA Textiles and Clothing Laboratory in a manner similar to that of other Federal granting agencies.

Related cooperative endeavors enable staff members of the USDA Laboratory to hold courtesy appointments in the College of Home Economics, Textiles and Clothing Department, and thus serve as co-directors of dissertations and/or theses, members of graduate student committees, guest lecturers, participants in seminars and short courses and as time permits, teaching and other Department activities. Involvement of graduate and undergraduate students in the Laboratory's research also illustrates and confirms that cooperation is a reality. Under the Broad Form Agreement, thirteen undergraduate and fourteen graduate students recently were employed on research projects. Specific agreements provided financial support for eight graduate research assistants and Laboratory personnel served on thirty graduate committees. The majority of these committees involved student research that contributed to joint projects of the Laboratory and the Department. The USDA Laboratory benefits in terms of a low overhead from its location in University facilities, and has much of its textile instrumentation in a temperature and humidity-controlled room in the Textiles and Clothing Department. Availability of graduate and undergraduate students to conduct research in the USDA facility is mutually beneficial to all, since it enhances the Federal research program and provides funding for students.

Members of both units believe that they share a unique opportunity to cooperate with each other. Such collaboration and benefits are highly valued. The mutual goal of both units is to maintain the excellent working relationship established.

DR. MARY CARTER

the university of tennessee

DEVELOPMENT OF RESEARCHABLE AREAS

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As an integral part of the long-range plans for cooperative research of the USDA Textiles and Clothing Laboratory and the College through the Department of Textiles and Clothing for the next decade, the following four researchable areas were identified: 1 Textile in Energy Conservation, 2 Clothing for People with Special Needs, 3 End-Use Performance of Textiles, and 4 Safety of Textiles Containing Additives and Contaminants. An overview and justification for each researchable area were developed with three or more specific projects listed as examples within each area. Each project includes a description of the problem, objectives, state-of-the-art, approach, user benefits, needed resources, and a glossary. Potential accomplishments are projected within present and increased levels of funding.

The researchable areas selected best meet the criteria of uniqueness, relevancy, and potential productivity. These areas are particularly appropriate for present and emerging thrusts for the cooperative endeavors of the two consumer-oriented Textiles and Clothing units located at The University of Tennessee, Knoxville. You are now invited to join us in visualizing and assessing the research needs in the areas of textiles and clothing for the consumer.

Ranking
I energy 24½
II end use 25
III Safety ~~23~~ 31
IV special needs 38

I. Textiles in Energy Conservation *

Justification: In the present use-energy age, clothing and textiles have been designed primarily to improve the aesthetic or non-thermal aspects of comfort. The thermal comfort of individuals in their homes, however, is a significant factor in whether thermostats are maintained at the household temperature levels recommended for conserving energy sources. Several physical parameters of the indoor air, space, and occupants are related to the ultimate comfort which can be expected indoors. Textiles used in contact or as indirect coverings can provide increased thermal comfort such that other energy-intensive parameters affecting comfort may be varied.

Consumers are seeking knowledge on drapery models, since 20 to 50% of the household heating cost is lost through draped windows which represent only 4 to 20% of the exposed surface area. Federal energy effectiveness studies call for greater insulation R-values than are usually present in flooring. R-values of carpet plus padding are generally one-fourth that of an insulated 2 x 4 stud wall. Cold spots on floors and walls affect the thermal radiation balance which ultimately relates to thermal comfort.

Because of the cost of textiles and the complexity of thermal comfort, simple solutions to this problem are not forthcoming or anticipated. Establishing models for home furnishings, apparel, and other textiles used indoors that lower energy requirements and provide thermal comfort at recommended or more conservative thermostat settings, is a new goal for consumer textile research.

Present Research: The performance characteristics of blankets and bedding are being studied in order to establish models for consumer selection, use, and care. The thermal performance of blankets is to be assessed with respect to relative warmth as opposed to absolute thermal protection at a depressed bedroom temperature.

The Department of Textiles and Clothing is conducting research to determine how the physical properties of shirting fabrics relate to their overall comfort at conventional thermostat settings; whereas, in the proposed research area, aspects relating to thermal benefits or warmth of indoor textiles will be emphasized.

* Underscored terms are defined or described in the glossary.

How can thermal comfort be achieved without using more energy?

A Thermophysical Properties of Textiles

Problem: Thermophysical properties of textiles are imporant with respect to the overall dynamic thermal response and insulation that textile assemblies afford. Thermal conductivity, specific heat, and heat transfer (conduction, convection, and radiation), fiber structure, chemical treatment, and manufacturing parameters and conditions are known to have an effect on functionality of textiles.

Objective: Identify and optimize important thermophysical properties of the textiles used in indoor applications for achieving thermal comfort.

State-of-the-Art: There have been recent investigations which demonstrated that changes in specific heat and thermal conductivity of fibers occur with changes in fiber density, orientation, draw ratios, chemical treatment, and encapsulation. The most innovative of these is a patent which describes the encapsulation of a gas in a solid phase in fibers which causes changes in fiber conductivity as the environmental temperature changes.

Approach: Evaluate differences and changes in heat transfer, thermal conductivity, specific heat, and other important thermophysical properties of textiles as they relate to aspects of thermal comfort. Assess the contributions which fiber structure, orientation, crystallinity, and fabric construction have on functional thermophysical properties. Evaluate various chemical finishes and treatments for their ability to cause changes in thermophysical properties, including use of such techniques as microencapsulation, phase changes, and related methodology.

Benefits: Optimization of such thermophysical properties would be useful to textile manufacturers for producing textiles having the best thermal comfort and insulation properties and to the consumer and business establishments for the selection of such materials. Appropriate use of these materials indoors should result in thermostat modification and concomitant savings to businesses and consumers by reduction of energy consumption in residences and office buildings.

Resources: Chemist
Physicist
Physical Science Technician
Graduate Students

Guarded hot plate

B. Fabric Assemblies for Thermal Comfort

Problem: The thrust of clothing fabric research has dealt with aesthetic aspects of garment comfort and serviceability. At the end of this "use-energy" age, clothing designers have offered less seasonal clothing and more year-round items. In the "save-energy" age we are entering, consumers and designers need information on selecting fabric assemblies to provide practical thermal comfort at the lower winter and higher summer temperature settings which are recommended.

Objectives: Identify properties of textile/fabric assemblies that contribute to estimates of clo value and translate clo value to clothing use; relate the above data to implications for conservation of energy used in interior heating and cooling.

State-of-the-Art: Research on thermal comfort factors and physiological aspects of clothing for the military is extensive. Most of this work is addressed to extreme climatic conditions and situations. In the past decade, independent R&D laboratories and fiber industry researchers have investigated the complex area of clothing comfort. However, the research literature does not reveal studies concerned with conservation of energy as a result of informed selection of fabric assemblies by wearers of clothing. A general practice of consumers is "adjust the thermostat" rather than make adjustments in fabric combinations of wearing apparel.

Approach: Select representative fiber/fabric combinations available to consumers. Determine insulation value of assemblies using measurements that simulate the microclimate for sedentary activity and depressed air temperatures. Develop garment assemblies indicative of optimum properties that contribute to thermal comfort of humans and assess with infrared thermography.

Benefits: The need to conserve energy and the escalating cost of energy are long-range problems. If concrete evidence is available which enables consumers to be thermally comfortable and at the same time reduce energy consumption, the outcome will be useful. For consumers on limited incomes and those who are less active, such as the elderly and the handicapped, information on the use of clothing to improve thermal comfort would be especially helpful.

Resources: Physicist
Home Economist
Graduate Student

Warmth tester
Thermovision camera

C. Models for Insulated Draperies

Problem: Conventional draped windows have one-sixth the thermal resistance of an insulated exterior wall. Windows make up from 4 to 20% of the exposed surface of residences, yet energy loss through windows accounts for 20 to 50% of the heating and cooling costs. Conventional draperies are designed for aesthetics and liberal use of energy. It is hypothesized that appropriate textile insulating materials incorporated into a drapery will increase thermal effectiveness for windows. A study is needed of the thermal energy efficiency of conventional drapery models using different fabricating techniques.

Objectives: Devise models for insulating draperies to produce solar benefit and doubled R-values and determine the effect of constructional insulating strategies on the heat transfer characteristics of seasonal window drapes.

State-of-the-Art: White plastic backing constitutes the major energy-saving advance in conventional draperies. Studies have shown that these drapes reduced winter heat loss by about 6% and summer heat gain by 33%. Tightly woven fabrics and good drape-to-wall seal have also been shown to increase thermal resistance.

Approach: Construct drapery prototypes incorporating structural partitions and other experimental insulating technology such that the drapes can be used conventionally. Measure the effective insultation value of the drapery prototypes under simulated end-use conditions without solar radiation using suitable laboratory instruments. Determine their thermal characteristics under solar loading with thermal stress and relate overall function in terms of energy expended indoors for thermal comfort.

Benefits: Knowledge of how to use textiles in drapes allows consumers to achieve thermal comfort at lower energy expenditures. Additional thermal benefits may allow indoor thermal comfort to be achieved by employing more conservative thermostat settings.

Resources:

- Physicist
- Textile Technologist
- Physical Science Technician
- Graduate Student
- Remote sensing infrared radiometer
- Solid state heat flow meter
- Collaboration with TVA/DOE to use rooms to test draperies

D. Bedding Models for Thermal Comfort

Problem: For many consumers, personal bedding is used to provide thermal comfort at bedroom temperatures that are slightly below the temperature maintained during the day. Government energy conservation measures recommend that thermostats be set 10^{o}F below the daytime setting. The choice and arrangement of textiles used in the bedding system contribute to the thermal comfort provided at a given temperature. A study is needed of the effects of layer placement on the thermal benefits of representative bedding and blankets in the microclimate developed during sleeping.

Objective: Establish the temperature and ambient conditions under which thermal comfort can be maintained employing bedding-use models.

State-of-the-Art: Blankets have been studied with respect to their physical properties and changes due to service in use. Work has begun on establishing the end-use failure mechanisms of blankets that shed lint. The use of impermeable layers in cold weather clothing, footwear, and blankets has been tested. The warmth to weight ratio of blankets and information on the clo value required to sleep in a 40^{o}F bedroom has been reported. The use of sheet blankets can reduce the initial chill encountered during the transition to thermal comfort.

Approach: Representative blankets, sheets, impermeable covers, and bed spreads will be selected. Models containing one or more blankets will be designed and tested using suitable heat-flow measuring instruments to determine clo value in bedding combinations. Experimental models using bedding articles will be tested. Clo values due to strategic layering in the bedding microclimate will be related to the air temperature and other thermal parameters important for thermal comfort. Bedding models will be evaluated and ranked with respect to effective general utility of textile layers.

Benefits: This study will supply practical knowledge regarding the optimum use of bedding for providing warmth at lower bedroom temperatures.

Resources: Physicist
Consumer Economist
Physical Science Technician
Graduate Students

E. Combined Effect of Textiles and Clothing on Thermal Comfort Indoors

Problem: Each textile product used indoors contributes to the overall thermal comfort of room and building occupants and to the thermostat settings employed. To minimize energy expenditure as it relates to prudent thermostat control, it is necessary to assess the effect that all textiles indoors have on thermal comfort. These textile materials include: draperies, wall coverings, upholstered items, carpets, rugs, wearing apparel, and bedding materials.

Objective: Evaluate the combined effect of textiles and clothing on thermal comfort indoors.

State-of-the-Art: It is anticipated that projects which antedate this one will have developed the necessary information to assess optimum thermal comfort characteristics of each textile item used indoors. However, the combined effect that these items have on thermal comfort at conservative thermostat settings has not been evaluated.

Approach: Combine and/or integrate the optimum parameters known or previously determined for each type of textile material used indoors as it relates to thermal comfort and changes in thermostat settings. Achieve this integration by utilizing an environmentally controlled room in which the window, wall, floor, and ceiling surface temperatures are monitored by remote sensing devices such as infrared thermal scanners or thermovision cameras. Monitor the six parameters known to be important for thermal comfort: air velocity, air temperature, mean radiant temperature, relative humidity, clothing insulation value (clo), and metabolic activity of room occupants. Translate overall effects of textiles used indoors into their efficiency for providing thermal comfort at conservative thermostat settings.

Benefits: Knowledge of the overall effect which textiles used indoors have on thermal comfort can be utilized by textile manufacturers, businesses, and consumers. Appropriate thermostat settings for residences, office buildings, hospitals, restaurants, hotels and motels, and other indoor structures, will result in reduction of operating costs for heating and cooling and reduction in energy consumption.

Resources:

Mechanical Engineer	Chemist
Physicist	Consumer Economist
Home Economist	Physical Science Technician
Graduate Students	Textile Technologist

Environmentally controlled room equipped with remote sensing devices, and other instrumentation needed to monitor and measure thermal comfort

GLOSSARY

CLO	Thermal resistance of the clothed body measured from the skin to the outer surface.
CRYSTALLINITY	The degree of structural order in a fiber or polymer.
DRAW RATIOS	A measure of the degree to which a polymer is stretched in order to increase its structural order.
ENCAPSULATION	Any process in which a material or its individual pieces or particles are coated or covered with, embedded in, or packaged in a plastic film, or sheath, or foam.
HEAT TRANSFER	The transmission of energy from one region to another as a result of a temperature difference between them. The science of engineering heat transfer deals with non-equilibrium situations, time effects, and solutions to practical problems.
INFRARED RADIOMETER	An instrument that measures the intensity of infrared radiation from an object.
INFRARED THERMOGRAPHY	A technique of portraying a surface temperature map of an object by use of scnning infrared cameras.
MEAN RADIANT TEMPERATURE	The uniform temperature of a simple black enclosure which would simulate the net radiant heat loss of a given person in a specific room setting.
METABOLIC ACTIVITY	Energy released by oxidation processes in the human body per unit time which is converted mostly to internal body heat and to a lesser extent external mechnical power.
ORIENTATION	Alignment of crystallite microstructure in polymers or fibers along a particular axis or axes which produces measurable directional effects.
R-VALUE	Thermal resistance or measure of resistance to flow of heat equal to the reciprocal of the coefficient of thermal conductivity.

SPECIFIC HEAT	The number of calories (heat quantity) needed to raise the temperature of one gram of material 1°C.
THERMAL COMFORT	That condition of mind which expresses satisfaction with the thermal environment.
THERMAL CONDUCTIVITY	A constant of proportionality (k) relating to the transport of energy between neighboring volume elements by virtue of a temperature difference.
THERMOVISION CAMERA	T.V.-like scanning camera that portrays an object and its temperature map using the thermal energy (infrared) radiating from the surface of the object.

II. Clothing for People with Special Needs *

Justification: People with special needs include individuals with orthopedic handicaps, visual limitations, infirmities due to the aging process, mental impairments, and those involved in hazardous situations arising from occupation, recreation, or athletics.

One of every ten persons in the United States is physically or mentally disabled. The disabled and aged represent sizable, neglected segments of the population whose needs have not been addressed. For many of these people, clothing presents or adds to problems of daily living. Encounters with physical surroundings and interactions with other people are mediated by body coverings worn for protection, comfort, and adornment. Personal impairments necessitate clothing that compensates for functional limitations.

Clothes that contribute to independence, comfort, safety, self-confidence, or recognition by others often are not available to the disabled. Until more is known about the special needs of these people and how clothing systems satisfy those needs, millions of people will remain dependent, non-participants in society.

Present Research: Dissertation research exploring the relation of selected family characteristics to parents' use of functional clothing for children with physical disabilities is near completion. The objectives are to determine degree of parents' use of functional clothing for children with physical disabilities; to collect information about solutions these parents develop for clothing problems; to develop a set of recommendations for use by professionals assisting families with similar problems.

* Underscored terms are defined or described in the glossary.

A. Garment Degradation from Orthopedic Devices

Problem: Persons with limb or joint dysfunction rely on orthopedic braces, splints, and other devices for assistance in movement. Assistive devices made of metal and other rigid materials reduce the use-life of the clothes worn with them. Garments wear out quickly in areas that rub against the devices.

Objective: Analyze the effects of surface wear from orthopedic devices on selected apparel fabrics and fabric assemblies.

State-of-the-Art: Generally, strong fabrics and reinforcement of stress areas are recommended as deterrents to abrasion damage, but few studies have analyzed fabric performance in functional clothing for disabled individuals. A limited wear trial of experimental garments indicated that a stretch denim of 75% cotton/25% nylon had better abrasion resistance than a non-stretch 100% cotton denim when worn over leg braces. However, little is known about how orthopedic devices damage a fabric, fabric properties that slow damage, or the similarity of fabric wear from different types of assistive devices. Reinforcement techniques have not been assessed for relative effectiveness in reducing damage or prolonging use life.

Approach: Analyze mechanics of the processes by which orthopedic devices damage selected fabrics; compare the effects of fabric wear by different orthopedic devices on fabrics of different weight and construction; investigate techniques for creating fabric assemblies that reduce damage and field test those assemblies in use with orthopedic devices.

Benefits: Identification of criteria for fabric resistance to wear from orthopedic devices will provide a basis for selection of appropriate apparel/fabrics for physically disabled individuals. Determination of effective reinforcement strategies will help the disabled reduce damage to clothing from assistive devices.

Resources: Home Economist
Textile Techologist
Graduate Students
Collaboration with rehabilitation personnel, brace makers

B. Relative Effectiveness of Different Incontinence Garments

Problem: Patients of all ages can be affected by urinary incontinence. Approximately 40% of nursing home residents in this country are incontinent. The management of incontinence involves use of hygenic aids to prevent soiling of patients and the near environment. Therapeutic requirements for hygenic aids are: (1) separates patient and excreta without harmful complications of infection, skin lesions, or odor; (2) preserves social independence, e.g., permits self-management; (3) keeps patient warm and dry; (4) is aesthetically acceptable. For ambulant patients, a protective undergarment is employed. Because diaper-type garments are offensive to adult egos, protective briefs are preferred. The ideal incontinence garment would be psychologically acceptable, lightweight, soft, cool, odor-free, water proof and would allow air to circulate. Non-disposable garments must be washable and durable to sanitizing methods.

Objective: Analyze the effectiveness of selected undergarments in meeting therapeutic needs of incontinent individuals.

State-of-the-Art: The development of reusable incontinence briefs has followed two approaches: (1) waterproof garments (plastic or plastic-coated) lined with removable insets or disposable pads or (2) knit garments of hydrophobic fibers (e.g., polyester, nylon, olefin) with fabric pouches or pockets to hold absorbent pads (thus placing a hydrophobic knit layer between patient and pad). Removable, reusable pads/liners have been made of layers of cotton flannelette, flannelette backed with olefin film, lanolin-coated polyvinyl chloride foam impregnated with disinfectant, polyethylene foam covered in jersey and backed with polyethylene film.

Little is known about the relative effectiveness of different fiber contents, fabric constructions, or pad arrangements in meeting therapeutic needs of ambulant, incontinent individuals.

Approach: Identify prevalent styles and fabrications in incontinence garments; compare selected pads/liners for absorbency, passage of water vapor, bulk, antibacterial action; compare durability to laundering of knitted, plastic, and plastic-coated pants; evaluate laundering and disinfecting techniques for decontamination of used garments; analyze effectiveness of laundering in preventing spread of bacteria from pants and liners to other items in laundry; compare ability of knit fabrics of different fiber content to serve as a semi-permeable barrier to fluid and an impervious barrier to bacteria.

Benefits: Determination of critical factors in predicting effectiveness of protective garments will provide information useful in establishing guidelines for selection/use of garments to enhance the well-being of incontinent individuals.

Resources:
- Home Economist
- Microbiologist
- Biological Science Technician
- Graduate Students
- Collaboration with hospitals, nursing homes, and other institutions
- Laboratory equipped to conduct microbiological research and/or collaboration with microbiology department on campus or in other institutions

C. Therapeutic Use of Garment Systems for the Mentally Ill

Problem: Recent trends in mental health care indicate that increasing emphasis will be placed on treatment of the mental patient (neurotic and psychotic) within the community rather than in a hospital environment. These trends are reflected in the increasing number of outpatient facilities and the considerably shorter periods of hospitalization. Presently there are approximately 515,000 mental patients occupying hospital beds. Mental illness is America's number one social problem with a cost of over $21 billion dollars a year. Psychiatric personnel use grooming and apparent interest in appearance as clues in diagnosing mental illness. Renewed interest in appearance is viewed as an indicator of recuperation, but specific details of the renewal process are unknown. Design and color of garments seem to be environmental elements that could be manipulated to achieve desired personality changes.

Objective: Investigate design and color of garment systems as they relate to changes in self-concept and perception of body image of the mentally ill.

State-of-the-Art: Fashion therapy projects, designed to acquaint patients in mental hospitals with current information on fashion and grooming, were judged successful if patients' appearance ratings improved or they displayed more interest in appearance or they participated in more social activities.

In comparisons of body image measures and fabric preferences of psychotic women, those with weak or blurred body-boundaries chose bright, highly saturated colors and strong figure-ground contrasts. It has been suggested that subjects with weak boundaries tend to define or reinforce them through clothing choices, but these conclusions are based on subjects' reactions to fabric rather than actual garments.

Approach: Develop experimental garments by alternating fabrics, colors, and design components. Two categories of garments will be designed: bright, saturated colors with strong figure-ground contrast; and light, low saturated colors with weak figure-ground contrast. Garments will be field tested with the mentally ill in a particular setting, such as hospitals and halfway houses. Subjects' perception of body image and self-concept will be compared before and after use of experimental garments.

Benefits: Knowledge will be generated relevant to use of clothing as a tool for the restoration of mentally ill individuals. This information would be valuable to social agencies, psychotherapists, educators, and rehabilitators who are involved in the treatment of the mentally impaired.

Resources: Home Economist
Textile Technologist
Graduate Students
Collaboration with psychiatric counselors, hospital personnel

D. Clothing Needs of the Elderly

Problem: Twenty million citizens of the United States are 65 years of age or older. Twenty percent of these have mobility limitations. Elderly people constitute the largest deprived group in America. They are deprived in terms of income, health care, nutrition, housing, clothing, acceptance and dignity - social and psychological well-being. Clothing is a tangible basic need and interest of people of all ages. Clothing not only provides protection against the elements, but the psychological aspects of clothing influence the social relationships of people. Elderly people with different life histories and living situations probably have different clothing needs which should be identifiable.

Objective: Identification of special clothing needs of persons over 65 years of age living in their own homes, retirement villages, and convalescent centers who represent different social, cultural, geographic and economic groups.

State-of-the-Art: Most research on the clothing of the elderly has focused on women's feelings about their wardrobes or attitudes toward market selections. Findings vary with the sample studied, but most elderly women seem interested in clothes and dissatisfied with clothing available. Elderly people have been treated as a homogeneous group; little empirical evidence exists identifying special clothing needs for different groups.

Approach: Elderly people over 65 years of age, representing groups from different social, cultural, geographic, and economic backgrounds will be interviewed. Questions will seek information about the basic and special needs of those over 65 years of age with and without handicaps. Compare special clothing needs of the elderly such as fabric characteristics and design features. Compare the clothing needs of the elderly living in their own homes, retirement villages, and convalescent centers within and across resident categories.

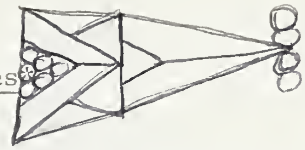
Benefits: Conclusions regarding special clothing needs of the elderly will help professional home economists, gerontologists, and social service personnel who work with the elderly to understand the relation of clothing to social and psychological well-being of older persons. Textile and apparel designers could use this information to market garments for the elderly.

Resources: Home Economist
Graduate Students
Collaboration with gerontologist, elderly professionals

GLOSSARY

BODY-BOUNDARY	An individual's perception and/or experience of the body wall as definite and firm or indefinite and weak.
BODY IMAGE	The way in which the body appears to ourselves.
FUNCTIONAL CLOTHING	Garments constructed or adapted to meet physical or psychological needs of individuals.
INCONTINENCE	Inability to prevent discharge of body excretions, e.g., urine.
ORTHOPEDIC DEVICE	Any kind of supportive appliance for the arms, hands, legs, feet, back, neck, or head, exclusive of temporary casts, slings, bandages, trusses, belts, or crutches.
SELF-CONCEPT	An organized configuration of perceptions of self which are admissible to awareness.

III. End-Use Performance of Textiles*



Justification: The structural design of a textile fabric is largely dictated by its end-use application and is restricted within predetermined limits of functional performance. In the case of fabrics intended for industrial applications, such characteristics can be unambigously defined in objective terms, such as weight, thickness, density, and mechanical properties and can be adequately controlled by selection of raw materials and methods of yarn and fabric production. On the other hand, in the case of apparel and household fabrics subjective factors, such as drape, handle, wrinkle recovery, crease resistance, pilling, snagging, texturing, softness and appearance also come into play. Consequently, rational design of apparel and household fabrics involves understanding of the mechanical properties that control these subjective characteristics and their correlation with end-use performance. The scope of the problem is further complicated by the availability of many new fiber types, encompassing a wide spectrum of physical and mechanical properties, and by the emergence of numerous yarn and fabric processing technologies.

Drape, handle, wrinkling, crasing, pilling, snagging involve complex deformations to which fabrics are subjected during use. It is only recently that the problem of controlling and predicting behavior of these aesthetic characteristics has received any concerted attention in the literature. In addition, the introduction of new types of fibers, yarns and fabric structures has made it essential that the textile scientist study their behavior if the consumer is to be advised on how to use the textile material effectively. Moreover, it will be important to obtain optimum use of textiles because rising raw material and production costs will be reflected by an increase in the price of consumer goods.

The failure of textile materials in use is another area which demands attention. The prediction of the service life of a garment by existing laboratory techniques (such as abrasion resistance) has proven unsuccessful. Such failure is caused by fatigue in various modes. Recent studies have attempted to show some correlation between fracture morphology of fibers obtained in laboratory studies and in actual wear. This type of investigation can help in understanding the causes and the nature of failure of textiles in use which will ultimately help the consumer.

Present Research: Preliminary studies in the area of fiber structure have been initiated. Presently, we are in the process of designing and fabricating a torsional fatigue tester. In addition, an experimental investigation regarding the influence of processing factors (such as time, termperature and pressure) on the bonding of nonwoven interfacing to base fabrics is being investigated. There are no ongoing studies which relate to the efficiency and the nature of bonding in thermally bonded nonwovens nor in other areas of research proposed under this heading.

*Underscored terms are defined or described in the glossary.

A. Failure Behavior of Fibers in Textiles

Problem: Failure of textile materials in use generally occurs due to fatigue of fibers. These fatigue mechanisms are the result of very complex deformations (such as the combination of one or more of the simpler forms: tensile, bending, torsion, shear, and friction) imposed during use. Until recently, the serviceability or durability of textile materials has been estimated or measured by laboratory abrasion tests or accelerated wear tests. However, the relationship between abrasion test results and the end-use performance is generally poor. The purpose of this investigation is to study the fracture morphology of fibers due to wear and environmental factors. This would hopefully help in the interpretation of results of fabric failure in wear.

Objective: Study the influence of environmental factors (such as moisture, heat, soiling) and wear on the fracture behavior of fibers and to determine the mechanisms that affect the failure of textiles.

State-of-the-Art: Recent studies in the literature have been concerned with the identification and classification of the kinds of fracture morphology observed in actual wear. Some investigations have dealt with the development of laboratory techniques which simulate the failure of fibers in use. Limited studies on the changes in fracture morphology during wear and those obtained on abrasion testers have also been reported. However, the influence of environmental factors which interact during wear cycle have not been fully investigated. A few recent studies indicate that techniques termed 'rotation over a pin' and 'bending abrasion tester' have produced fatigue failures in fibers which closely resemble fracture morphology found in fabrics that failed during wear. However, one major mode of fiber failure, i.e., torsional fatigue mode, has been totally ignored.

Approach: The fracture morphology of representative fibers in apparel and the influence of environmental factors on the failure of fibers will be evaluated. Textile materials representing fiber types intended for use in apparel will be selected. The garments will be subjected to an extensive wear studies while the garment material will be tested for estimated serviceability by abrasion instruments. The fracture morphology of various fibers from the garment fabrics will be obtained by well defined laboratory techniques. The influence of environmental factors on failure will be studied in garments as well as on single fibers and yarns. Changes in the fracture morphology of fibers will be observed in a scanning electron microscope. An attempt will be made to work out analytically the mechanisms of rupture in the torsional fatigue mode.

Benefits: An understanding of the influence of various environmental factors and wear on the serviceability of textile materials will benefit the textile and allied industries and especially the consumer. Results will form the basis for development of test methods and techniques for the laboratory evaluation of textiles and prediction of wear life of textile materials.

Resources: Physicist
Graduate Students
Scanning electron microscope

B. Influence of Fiber, Yarn and Fabric Structure on Snagging of Knits

Problem: Snagging is not a new phenomenon. Snags and picks in women's lingerie and hosiery have long been problems. However, the same rate of snagging in fabrics for women's and men's outerwear is not acceptable and is costly to consumers. Snagging under service conditions is inadvertant, unintentional, and undesirable since the snagged material mars the surface of the fabric and at the same time, mars the symmerty of the fabric construction to varying degrees ranging from a local pucker to holes or runs in certain knitted fabrics. Snagging a weft knit fabric, for example, may result in the collapse of several stitches or loops across the fabric. Premature discarding of garments is often associated with snagging of fabrics. In some instances, diminished serviceability is due to snagging. It is therefore important to study the mechanism of snagging and understand the influence of fibers, yarns, and fabric structures on this complex phenomenon.

Objectives: Develop a theoretical understanding of the mechanism of failure of knitted structures due to snagging and delineate the influence of fiber, yarn, and fabric structure on snagging propensity.

State-of-the-Art: Many studies have dealt with the analysis of knitted fabric geometry under relaxed conditions. Other research has been concerned with the failure behavior of knitted structures subjected to both uniaxial and biaxial stresses. However, only one theoretical study analyzed snagging behavior of women's sheer hosiery. Several attempts have been made to develop laboratory techniques that simulate the snagging of fabrics in actual wear, but none has proven successful. The work reported in the literature on the influence of fiber, yarn, and fabric structural properties on the snagging failure of fabrics is sketchy.

Approach: Simple and complex knitted fabrics representing different fiber content and yarn construction will be obtained in experimental widths and yardages. Fabric geometry (such as fiber shape or contour and physical properties, yarn construction, stitch constructions, fiber/yarn friction, shear, buckling, or stretch/recovery) will be related to mechanisms of snagging, plucking, and the force required to withdraw a yarn caught by an asperity. Data will be compared with those obtained on available laboratory or modified instruments.

Benefits: Both manufacturers and consumers will benefit by anti-snag knitted fabrics. An understanding of the mechanisms and the parameters that influence snagging will help the textile technologist in designing structures that reduce or eliminate snagging. Consumers will be able to obtain and be satisfied with fabrics having better appearance and prolonged serviceability.

Resources:		
	Physicist	Experimental fabrics
	Chemist	
	Home Economist	
	Graduate Students	

C. Pilling Phenomenon in Textiles

Problem: The problem of pilling and other changes in surface appearance, such as fuzzing, that occur in normal wear has become more acute with the introduction of new fibers and fabrics. Pills may not affect the actual durability of a garment but the deterioration in appearance is such that garments are rendered quite useless. Pills are the bunches or balls of tangled fibers held to the surface of a fabric by one or more fibers. Pilling is affected by type of fiber or blends, fiber dimensions, yarn and fabric construction and fabric finishes.

Objective: Identify factors which cause fabrics to exhibit different pilling propensities and establish the relations between fabric geometry and pilling propensity.

State-of-the-Art: Man-made fiber producers have funded research on pilling of synthetic fibers in apparel fabrics. Several instruments and test methods have been proposed to evaluate pilling propensity. No laboratory results have correlated with pill formation in wear. The effect of chemical finishes on the prevention of pilling of cellulosic fiber or fiber blends has not been studied.

Approach: Loosely knitted and tightly knitted single jersey and more complex fabrics will be produced from open-end and ring spun yarns of cotton, cotton/polyester, cotton/rayon, cotton/acrylic, or rayon/polyester. Light and heavy weight plain and twill weave fabrics of all cotton or blends will be obtained. Standaridized or modified test procedures will be used to detect the mechanisms of pill precursors, pill formation, and pill break-off produced under controlled conditions. States of pill production and range of pilling will be evaluated by microscopic techniques, physical means, and by observers. Chemically finished fabrics will be compared with unfinished knits.

Benefits: Consumers and industry will benefit by production of pill-resistant fabrics for longer wear garments. An understanding of the mechanism and paramters that influence pilling or surface distortion will help the textile and related industries.

Resources: Chemist
Physicist
Home Economist
Physical Science Technician
Graduate Students

D. Low-Load Deformation and Recovery Behavior of Textiles

Problem: Major consumer problems and complaints with cottor or other fiber knits are sagging, bagging, or buckling in areas of stress, such as knees or elbows. This unsatisfactory performance appears to be related to a textile's stretch and recovery properties. Research on causes and prevention of bagging has not been reported. Instrumentation and test methods are not available.

Objective: Develop theoretical models of the mechanisms of sagging or bagging in knitted fabrics as related to fabric geometry.

State-of-the-Art: Synthetic fiber producers are aware of the problem. However, results of any in-house research have not been reported. A major fabric producer proposed an accessory for a tensile tester. This accessory was aimed at testing polyester double knits, but it has not been accepted or used by other companies or organizations.

Approach: Simple and complex knits representing selected fiber contents, yarn geometry, and fabric finish will be obtained. Cyclic increments of stress will be applied by instrumentation and procedures develoepd on an experimental scale. Rate and extent of bagging will be monitered instrumentally and photographically. Relation of fabric parameters, such as fiber shape and tenacity/elongation, to stages of bagging will be explored. Correlation between mechanisms of bagging under laboratory conditions and in full scale garments will be established in a pilot study.

Benefits: Understanding the fundamental mechanisms for preventing bagging in knitted fabrics can lead to increased use and satisfaction with cotton or cotton blended knits. Fewer garments will be discarded. Elimination of bagginess in otherwise serviceable and comfortable fabrics for garments will improve the family's use of resources.

Resources: Chemist
Physicist
Home Economist
Textile Technician
Graduate Student

E. Factors Influencing Mechanical Properties of Thermally Bonded Nonwovens

Problem: One of the most important properties of a nonwoven is its strength as this ultimately determines wearlife and durability. The problem that exists is that it is possible to construct nonwoven materials that are quite strong but rather stiff, or quite drapeable but rather weak. Factors such as fiber properties and processing conditions contribute to the strength of a nonwoven fabric, but strength is principally dependent on the nature and extent of interfiber bonding. A balance of properties in nonwoven fabrics is needed if they are to be successfully used in various end-use applications.

Objective: Study the relationship between fiber structure and the nature of bonding in thermally bonded nonwoven materials, and the influence of bonding on the physical characteristics of a particular end-use product.

State-of-the-Art: Research in the area of nonwoven fabrics has been on the increase in the past 20 years and is still basically in the frontier era of its development. Early studies dealt with the mechanical properties of a nonwoven and how it is affected by its finder and other components. More recent studies are concerned with studying the make-up of nonwovens. For example, in certain apparel applications researchers have determined that bending rigidity and resistance to shear are the factors that make the use of a nonwoven a problem. Theoretical studies have been developed on how nonwovens should be produced to improve these factors; however, additional basic research is needed. The research literature does not reveal any studies that have dealt with fiber structure variations and bonding characterization.

Approach: Polyester fibers of varying modulii (stiffness) will be procured. Some fibers will have a 3-dimensional crimp and others will be used in the straight formation. The fibers will be processed into nonwoven sheets and thermally point bonded. Variables included are: various modulii, two fiber textures, types of nonwoven sheets - all crimped fibers; all straight fibers; mixtures of both crimped and straight fibers. The fabrics will be evaluated for such properties as bending rigidity, shear, repeated flexing and drape. The nature and the quality of bonding will be evaluated by mechanical and scanning electron microscope techniques.

Benefits: This study will benefit the utilization of nonwoven textiles in areas such as garment construction, including apparel manufacturing and home sewing, household textiles, and the medical and sanitary supply field. The forecast for fabrics available to the consumer includes many light weight and sheer materials, but the adaptability of nonwoven materials to these fashion fabrics has presented a problem. This study will help consumers in obtaining more satisfactory materials and better serviceability.

Resources: Graduate Students
Polymer Scientist
Collaboration with The University of Tennessee Engineering Department

GLOSSARY

ASPERITY	Protrusion from a rough surface.
BAGGING	Out of plane deformation of a fabric or a garment, e.g., protrusion of a fabric around the knee area.
BIAXIAL STREESS	Stresses applied along two principal directions perpendicular to each other.
BUCKLING	Out of plane deformtion caused by folding of a fabric, bending of a sleeve or trouser's leg; influenced by the bending rigidity and frictional behavior of fibers and yarns.
CRIMP	The waviness of a fiber.
DRAPE	The way a fabric hangs down in folds, a complex fabric deformation that provides aesthetics.
DURABILITY	Ability of a garment to withstand normal washing, drying and wearing.
FATIGUE	Deterioration in mechanical properties or catastrophic failure brought about as a consequence of repeated deformation at levels less than the static limit of the material.
FRACTURE MORPHOLOGY	Nature of broken or fractured surfaces.
FUZZING	Hairiness - protusion of fiber ends from a yarn of a fabric.
HAND, HANDLE, FEEL	Synonyms; sum total of the sensations experienced when a fabric is touched, flexed, smoothed, or handled.
INTERFIBER BONDING	Bonding between two or more fibers achieved either by the incorporation of an external binder (such as a latex) or by melting the thermoplastic fiber polymer material by the application of heat and pressure.
LOW-LOAD DEFORMATION	Deformation of materials obtained under loads lower than their elastic and failure limits.
NONWOVEN	Planar structures made from fibers or yarns by systems other than interlacing or looping of yarns.

OPEN-END SPINNING	Systems for producing spun yards by a process in which sliver or roving is opened to individual fibers or tufts and is subsequently reassembled in the spinning element (e.g., turbine into a yarn).
PILLING	Small accumulation of fibers in bunches on the surface of a fabric.
RING SPINNING	A continuous method of processing yarn. Roving is drafted (drawn out) into yarn and twisted to final size and wound on bobbins (holders).
SERVICEABILITY	The useful life of a textile or garment; this refers to the retention of appearance, aesthetic and strength properties of a fabric.
SHEAR	Movement of yarns relative to each other in the plane of the fabric deformation of a fabric with change in volume.
SINGLE JERSEY	Weft knitted jersey.
SNAGGING	Pulling of threads, course wise in weft knitting or wale wise in warp knitting.
THERMALLY BONDED NONWOVENS	Fabrics made from the thermoplastic fibers (such as nylon, polyester, polypropylene) bonded by the application of heat and pressure.
TORSIONAL FATIGUE	Fatigue induced in a fiber due to twisting and untwisting.
UNIAXIAL STRESS	Stress applied along a principal axis of a fiber, yarn, or a fabric.
WEARLIFE	Useful life of a garment.

Vigo Nov. '76

IV. Safety of Textiles Containing Additives and Contaminants*

Justification: The recent concern and focus on the safety of various chemical additives to food and fiber are reflected by the passage of the Toxic Substances Control Act (TSCA). This Act will have a great impact on the textile industry and on the types of textile products offered to the consumer. The American Association of Textile Chemists and Colorists recognized the importance of such legislation and has recently formed a committee which will disseminate technical information to the textile industry on possible hazardous chemical additives used in processing and finishing. Also, the role of the National Institute of Occupational Safety and Health (NIOSH), the Occupational Safety and Health Administration (OSHA), and the Environmental Protection Agency (EPA) in occupational and environmental safety and health may have impact on the application of agricultural chemicals to crops, and whether clothing worn by field workers in these applications is safe and suitable.

The burden of proof will be on the chemical supplier, fiber producer, textile manufacturer, and agribusiness to insure that textile additives and contaminants are safe by providing toxicity and efficacy data. However, the identification, separation and determination of the amounts of textile additives and contaminants is information needed to arrive at making decisions with regard to environmental impact and consumer and worker safety and health. Recommendations for refurbishing of textile products containing textile contaminants, and methods of removing or minimizing these contaminants, also need to be developed.

Present Research: There are presently no projects in progress in this area at either the USDA Laboratory or in the Department of Textiles and Clothing at The University of Tennessee, Knoxville.

* Underscored terms are defined or described in the glossary.

A. Determination of Dye Carriers in Textile Products

Problem: Various organic compounds are utilized as carriers for dyeing textiles, particularly polyester. Some of these carriers, such as halobenzenes, diaryl ethers, and phenols, are already coming under scrutiny for increasing stream pollution. EPA has recently stated that very little is known about dye carriers with respect to their toxicity and environmental effects; further studies are planned. Even less is known about the amounts of dye carriers present on marketed textile products and the amount of these substances retained on textiles after conventional laundering processes.

Objective: Identify, separate, and quantitatively determine amounts of dye carriers in textile products by analytical techniques.

State-of-the-Art: Recent studies have investigated the identification and separation of dye carriers by thin layer and gas-liquid chromatography. Preliminary investigations indicate that aromatic ethers and hydrocarbons and phenols are more problematic than other dye carriers with respect to their effluent discharge and LD_{50} toxcity profile. However, little information exists on the amount of carriers retained in textile products offered to the consumer and whether these substances are removed by laundering or dry cleaning.

Approach: Select representative textile products known to have dye carriers used in their processing and manufacture; identify carrier types and estimate amount of carrier by use of spot tests, thin layer and gas-liquid chromatography, infrared spectroscopy, and other appropriate analytical techniques. Launder and/or dry clean textile products by recommended refurbishing instructions, and ascertain if carrier concentration present in the textile decreases or is removed as the material is refurbished.

Benefits: Separation, identification, and determination of amounts of dye carriers in textile products on the market will provide information for manufacturers and responsible regulatory agencies to make decisions with regard to what effect these substances have on the environment and on human health and safety relative to the benefits of their use in textile products.

Resources: Chemist
Graduate Students

A gas-liquid chromatograph capable of detecting dye carriers in the parts per billion (ppb) range
Dry cleaning equipment

B. Contamination of Work Clothes by Boll Weevil-Eradicants

Problem: Application of pesticides, herbicides, and related pest control agents to agricultural crops is an integral and important part of farming and agricultural research. However, some questions have been raised regarding chemical contamination of clothing worn by field workers in application of agricultural chemicals to crops. There is a need to develop information on the most appropriate clothing to be worn in this regard, as well as establishing the extent to which clothing contamination occurs on application of specific pesticides and related substances.

Objectives: Determine the degree of contamination of clothing worn by field workers in the application of boll weevil eradicants and make recommendations for the most suitable clothing to be worn in these applications.

State-of-the-Art: Preliminary studies have shown that clothing worn by field workers in application of the insecticides DDT and methyl parathion is contaminated with substantial amounts of these materials. In a limited study, shirts worn while applying the boll weevil eradicant diflubenzuron did not show any detectable chemical residues at the 20 parts per billion level.

Approach: Evaluate apparel (shirts and trousers) worn by field workers in the boll weevil eradication program for concentration of diflubenzuron down to the level of 1 ppb by use of gas-liquid and high pressure liquid chromatography. Develop reliable separation and extraction procedures for separating this material from other textile finishes and chemicals present on this clothing worn in the field. Determine the most appropriate recommendations for the most suitable apparel in this regard.

Benefits: Information developed on the amount of diflubenzuron present in clothing worn by field workers and recommendations for laundering procedures and suitable apparel are important. The USDA can make assessments of the relative benefit/risk of applying these chemicals for a high priority boll weevil eradication program. Such information would also be useful for regulatory agencies, particularly OSHA and EPA, in reaching decisions on environmental impact and human safety and health.

Resources:		
	Chemist	High pressure liquid chromatograph
	Graduate Students	Collaboration with entomologists and field workers in the USDA Boll Weevil Eradication Program
	Physical Science Technician	

C. Determination of Free Formaldehyde in Apparel

Problem: Durable-press fabrics constructed of polyester/cotton blends or of all cotton crosslinked with formaldehyde-containing resins have gained widespread consumer acceptance. Recently, some questions have been raised concerning the safety of long-term exposure to fabrics containing formaldehyde. The Japanese have adopted a strict standard regarding the amount (concentration) of free formaldehyde permissible in a durable-press fabric. The problem proposed is to determine free formaldehyde levels in a variety of consumer durable-press products.

There is no intent in this study to make a determination of the danger to the consumer posed by such fabrics. The intent is merely to provide information on formaldehyde content and change in formaldehyde content of various typical consumer durable-press products, so that information is available in the event that a move towards standardization develops in this country.

Objective: Determine free formaldehyde levels of representative durable-press consumer products at the time of purchase and after selected intervals of laundering and drying.

State-of-the-Art: The technical and patent literature abounds with studies and disclosures relating to durable-press technology. Analytical methods for identification of various types of formaldehyde-containing resins are well established, as are test methods for determination of free formaldehyde. Techniques for identification include the use of infrared spectroscopy and thin layer chromatography (TLC). Studies reporting the change in fabric properties of durable-press fabrics with laundering exist. However, studies relating changes in fabric properties (durable-press rating, wrinkle recovery angle, tensile strength) to changes in level or availability of formaldehyde are not reported.

Approach: Consumer durable-press products covering a range of top and bottom weights will be purchased at retail outlets. Products selected will include various polyester/cotton blends and all cotton fabrics in sheet, shirt, blouse, or slack constructions. Resin systems will be identified by standard techniques, and free formaldehyde will be determined by known or devised analytical methods. Fabrics will be subjected to a sequence of launderings and dryings, and free formaldehyde levels will be determined after each.

Benefits: Several benefits will be derived from this study. The range of free formaldehyde levels in typical consumer durable-press goods (as pruchased) will be available to serve as a benchmark for comparison of similar goods produced in future years. Change in free formaldehyde level with laundering will identify resin systems which have different tendencies to release or retain formaldehyde. In the event that regulation or standardization of formaldehyde levels in durable-press products becomes a consideration for a regulatory agency, information will be available to provide background for decisions.

Resources:	Chemist Graduate Students	TLC apparatus Infrared spectrophotometer for quantitative analysis

D. Chemicals Extractable from Flame-Resistant Fibers

Problem: The use of chemical finishes to provide flame resistant (FR) fabrics has fallen into considerable disfavor as a result of the recent disclosures relating to the toxicity, carcinogenicity, and mutagenicity of such finishes as Tris and Fyrol. More and more FR articles are appearing which make use of inherently FR fibers (modacrylic, matrix fibers) or fibers which incorporate an additive in the polymer to incorporate flame resistance (PFR rayon, PFR acetate, PFR polyester). The problem proposes is to examine these fibers to determine the identity and amount of any extractable chemicals which they may contain. The intent is not to make a determination of the danger to the consumer posed by these fabrics.

Objective: Identify and quantitatively determine chemicals extracted from inherently FR and PFR fibers.

State-of-the-Art: Standard analytical techniques for qualitative and quantitative analysis of fibers are well established. Extractable materials can be identified qualitatively by chromatographic methods, by spot tests, and in some cases by infrared spectroscopy. Quantitative analytical techniques include chromatography, ultraviolet and visible spectrophotometry and wet chemical methods. Choice of quantitative technique depends upon the nature of chemicals extracted and identified. Various extraction techniques differing in power are available. Chemical analysis of extractables from inherently FR or PFR fibers is not well documented at this time.

Approach: Children's sleepwear or other apparel items made from either inherently FR or PFR fibers will be obtained from retail outlets. Samples will be subjected to differing extraction procedures. Extracts will be analyzed qualitatively following classicial analytical pathways. After extracted materials are identified, appropriate quantitative procedures will be employed so that chemicals extracted from fibers of these types will be completely characterized.

Benefits: Several benefits will be derived from this study. The nature of chemcials extractable from inherently FR and PFR fibers will be known. This could be of interest to toxicologists and would also serve as a benchmark for comparison of similar goods produced in future years. The relative merits of inherently FR fibers as a class could be compared to that of PFR fibers with respect to chemical content.

Resources: Chemist
Graduate students

E. Monomers and Spinning Solvents Retained in Acrylic Textiles

Problem: Acrylic and modacrylic fibers are currently used in a variety of textile products. The preparation and processing of these fibers leaves residues of monomers such as acrylonitril and methyl acrylate. OSHA has recently set strict standards for occupational exposure to these monomers because of their high toxicity. Acrylic fibers spun in solvents such as dimethyl formamide (DMF) contain residual amounts of these solvents. It is not known to what extent monomers or spinning solvents are retained in textile products from acrylic fibers during their normal end use.

Objective: Determine by analytical methods amounts of monomers and solvents retained in textile products made from acrylic fibers.

State-of-the-Art: The monomers acrylonitrile and methyl acrylate have been identified in acrylic fibers by gas-liquid chromatography. Residual amounts of solvents used in the spinning of acrylic fibers have also been determined by similar techniques.

Approach: Evaluate representative acrylic and modacrylic textile products for their contamination with the monomers acrylonitrile and methyl acrylate by a variety of analytical techniques, such as thin layer chromatography, gas-liquid chromatography, and infrared spectroscopy. Relate concentration of monomers retained in the textile products to laundering or dry cleaning processes appropriate for their end use. Use similar strategies to detect, estimate, and predict amounts of spinning solvents retained in acrylic textile products. Solvents would include DMF, dimethyl acetamide (DMAC) and N-methylpyrrolidone, and other frequently employed spinning solvents.

Benefits: Information regarding the amounts of monomers and spinning solvents retained in acrylic and modacrylic textiles may be used to ascertain whether such residues constitute a health or safety hazard. If such a hazard exists, methods for reducing or eliminating such contaminants from acrylic and modacrylic textile products may be devised so that these products will continue to be offered to the consumer.

Resources: Chemist
Physical Science Technician
Graduate students

GLOSSARY

ACRYLIC	A manufactured fiber in which the fiber-forming substance is any long chain synthetic polmer composed of at least 85% by weight of acrylonitrile units $(-CH_2-\underset{CN}{CH}-)_n$.
CHROMATOGRAPHY	An analytical technique for the separation and identification of chemical compounds in complex mixtures by flow of a mobile phase (gas or liquid) over a stationary phase (solid or liquid).
DIFLUBENZURON	Common name for the boll weevil eradicant N-[(4-chlorophenyl) amino] carbonyl]-2, 6-diflurobenzamide.
DYE CARRIERS	Organic compounds which function as swelling agents for hydrophobic fibers and increase the rate of diffusion of the dye into these fibers.
EFFLUENT DISCHARGE	Gas or liquid waste products from chemical or industrial plants emerging from a pipe or similar outlet.
LD_{50}	That quantity of substance administered either orally or by skin contact necessary to kill 50% of exposed animals in laboratory tests within a specified time.
MATRIX FIBERS	Synthetic fibers composed of two firmly but separately combined polymers of different chemical or physical structure in which the polymers are arranged in the form of a heterogenous mixture.
MODACRYLIC	A manufactured fibers in which the fiber-forming structure is any long chain synthetic polymer composed of less than 85%, but at least 35% by weight of acrylonitrile units $(-CH_2-\underset{CN}{CH}-)_n$.
PFR	Permanently flame resistant.
SPECTROSCOPY	Observation of the wave length and intensity of light, or other electromagnetic waves, absorbed or emitted by various materials.
TENSILE STRENGTH	Grams or pounds of force required to rupture a structure (e.g., fibers, yarns, or fabrics).

RESOURCE NEEDS

In considering additional resource needs, it should be noted that the staff of the USDA Textiles and Clothing Laboratory and the Department of Textiles and Clothing at The University of Tennessee, Knoxville appreciate the present resources available to them and the opportunity and challenge to cooperatively use these resources in the best interest of consumers of textile products. Moreover, location at a major Land-Grant university gives the staff access to libraries, equipment, instrumentation, and other supporting resources. The collective expertise of both organizations consists of 10 professionals, by far the greatest and most significant resource.

If additional resources are granted, space for expansion is available. Although space is limited in the College of Home Economics and the Department of Textiles and Clothing, the University has made a building available to the USDA Textiles and Clothing Laboratory. This building was remodeled, and has the capacity for housing additional staff and graduate students for cooperative efforts.

Relevant and pertinent research opportunities that will contribute to making consumers more knowledgeable in the selection, care, and use of textiles, as well as the current need to train graduate students in areas of consumer interest, have prompted the development of the four researchable areas. The proposed research projects will be pursued as current projects are completed. However, when additional staff and operating funds are available, the research time and effort needed to implement and complete these projects will be enhanced. At current resource levels, approximately one-third of the listed projects will be completed within a seven year period. Presently, about $75,000 per scientist in constant dollars is considered a minimum amount to initiate a specific project. This level of funding provides equipment, graduate student employment and technical personnel for most projects. Your support is solicited to implement the projected textiles and clothing research areas that are designed to provide timely and relevant information to consumers.

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NOTES